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Del Frate et al.

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(54) **VALVE ASSEMBLY FOR AN INJECTION VALVE, INJECTION VALVE AND METHOD FOR ASSEMBLING A VALVE ASSEMBLY OF AN INJECTION VALVE**

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USPC 239/533.1–533.12, 584, 585.1, 585.3, 239/585.4, 585.5; 123/299, 446, 447, 467, 123/468
See application file for complete search history.

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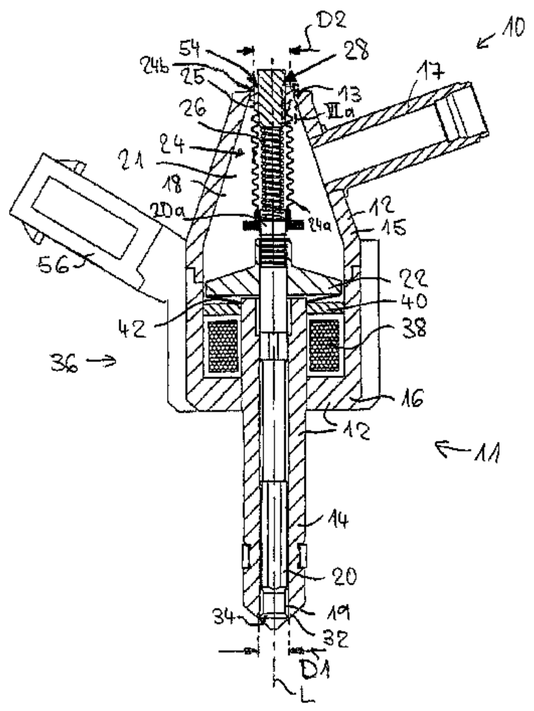
(57) **ABSTRACT**

A valve assembly for an injection valve and a method for assembling a valve assembly are provided. The valve assembly includes a valve body with a central longitudinal axis and having a cavity with a fluid inlet portion and a fluid outlet portion, an end portion being arranged at an axial end facing away from the fluid outlet portion, and a seat being arranged at an axial end of the valve body facing the fluid outlet portion. A valve needle is axially movable in the cavity and prevents a fluid flow through the fluid outlet portion in a closing position and releases the fluid flow through the flu-id outlet portion in further positions. The valve needle has an axial end facing away from the fluid outlet portion and facing the end portion, and a seat part resting on the seat of the valve body in the closing position. A contact area between the seat part and the seat of the valve body has a first outer diameter. The valve assembly includes an electro-magnetic actuator unit being designed to actuate the valve needle. A bellow arrangement includes a bellow and an end portion, the bellow is fixedly coupled to the end portion in a coupling area. The coupling area has a second outer diameter. The first outer diameter is equal to the second outer diameter.

5 Claims, 4 Drawing Sheets



(51) **Int. Cl.**

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F02M 61/20	(2006.01)
F02M 63/00	(2006.01)
F02M 65/00	(2006.01)
F02M 61/12	(2006.01)

(52) **U.S. Cl.**
CPC ***F02M 61/168*** (2013.01); ***F02M 61/205*** (2013.01); ***F02M 63/0057*** (2013.01); ***F02M 65/005*** (2013.01); ***F02M 61/12*** (2013.01)

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Fig. 1

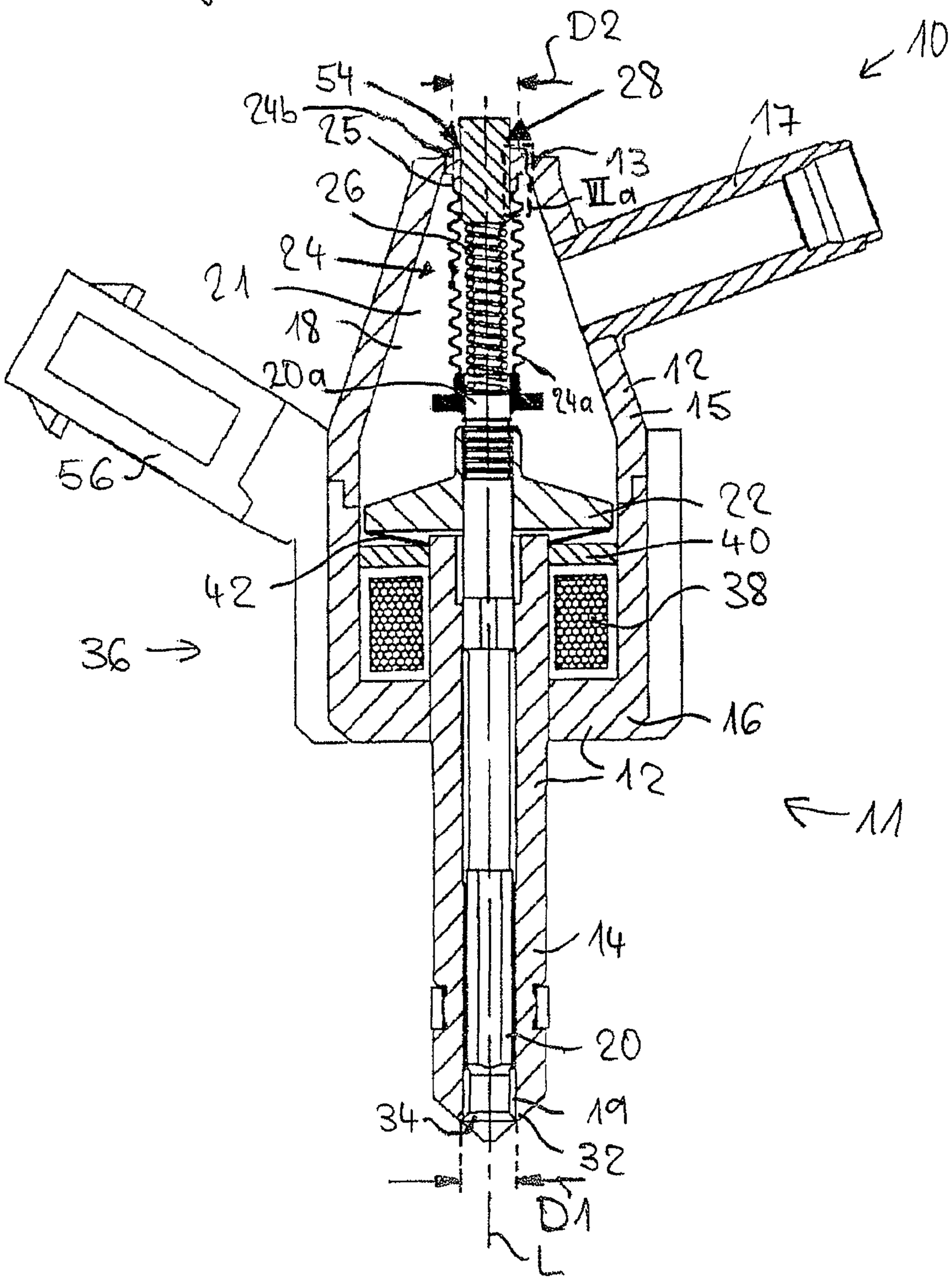
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Fig. 1a

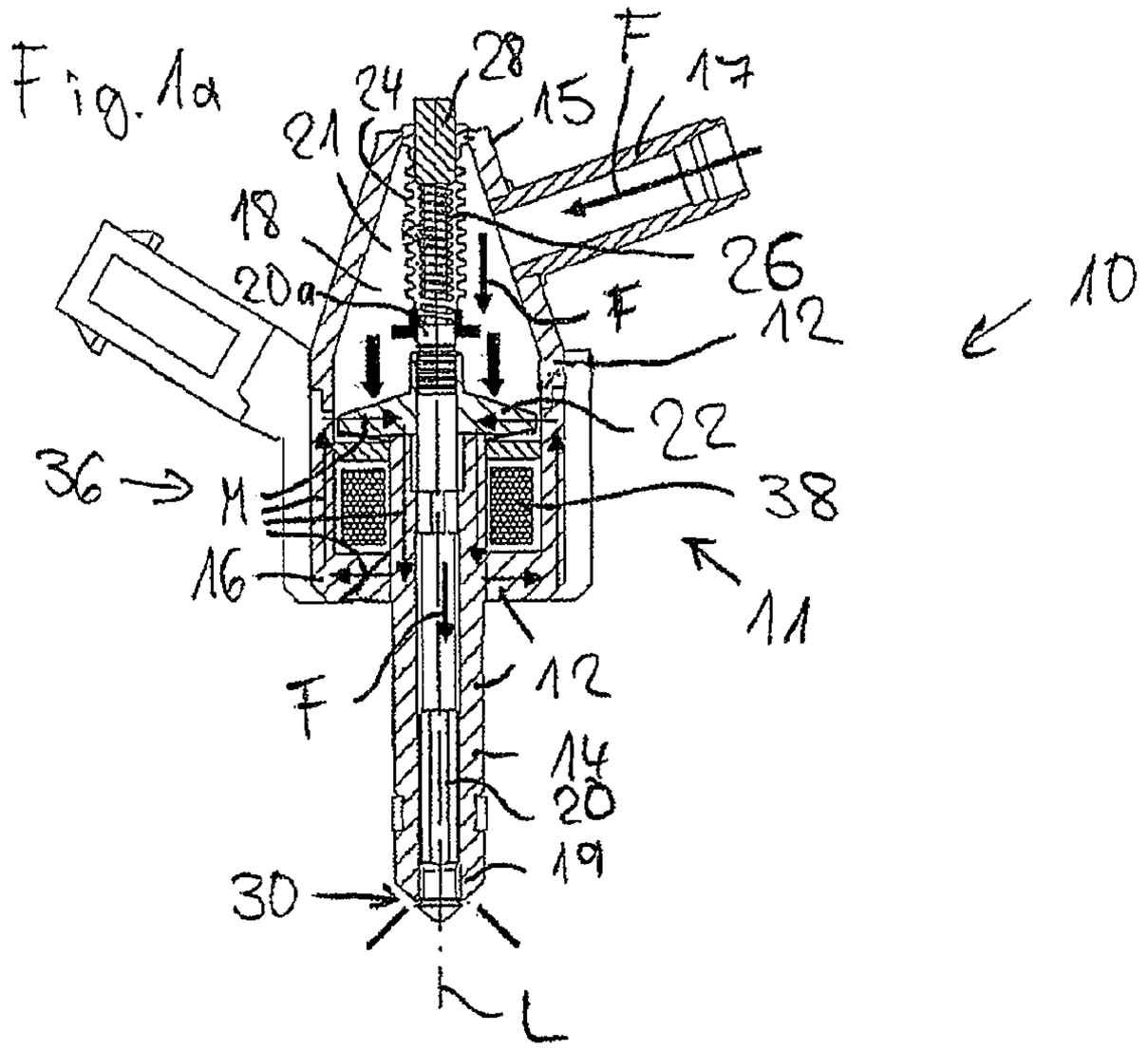


Fig. 2

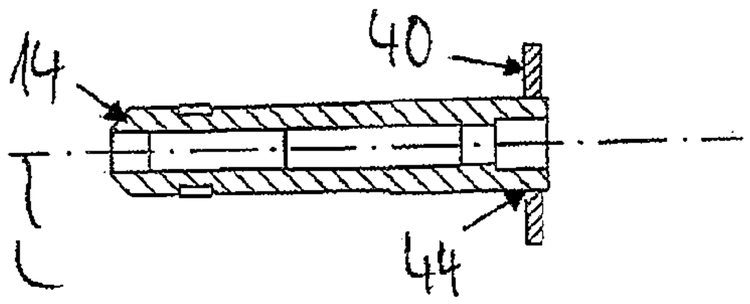


Fig. 3

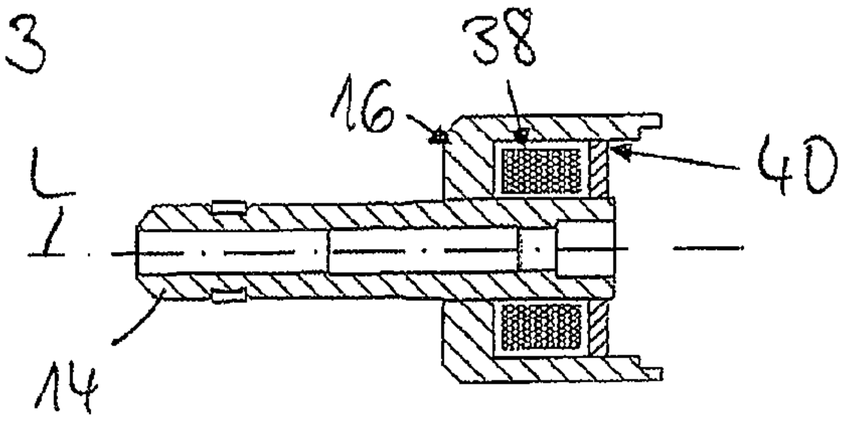


Fig. 4

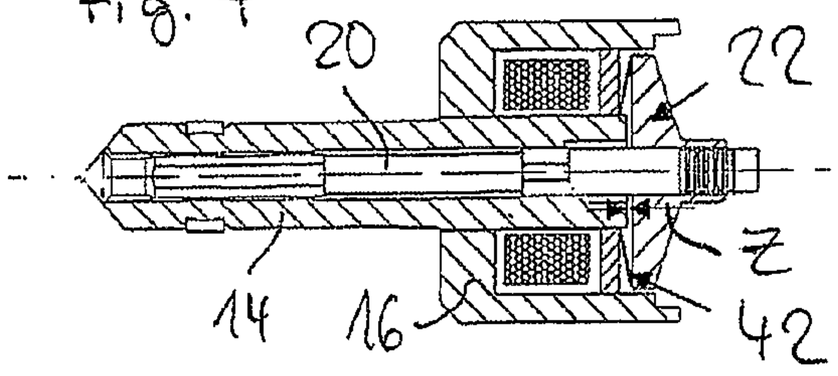


Fig. 4a

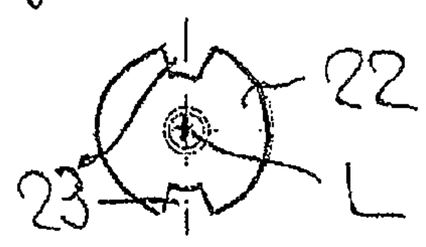


Fig. 5

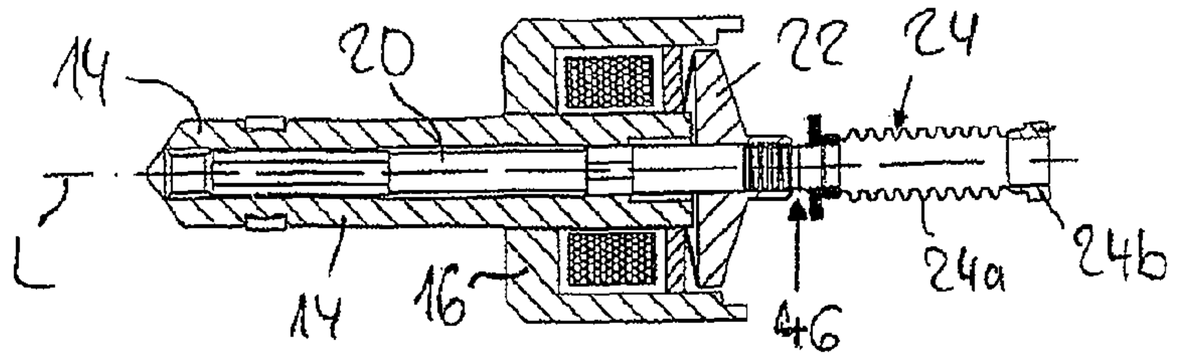


Fig. 6

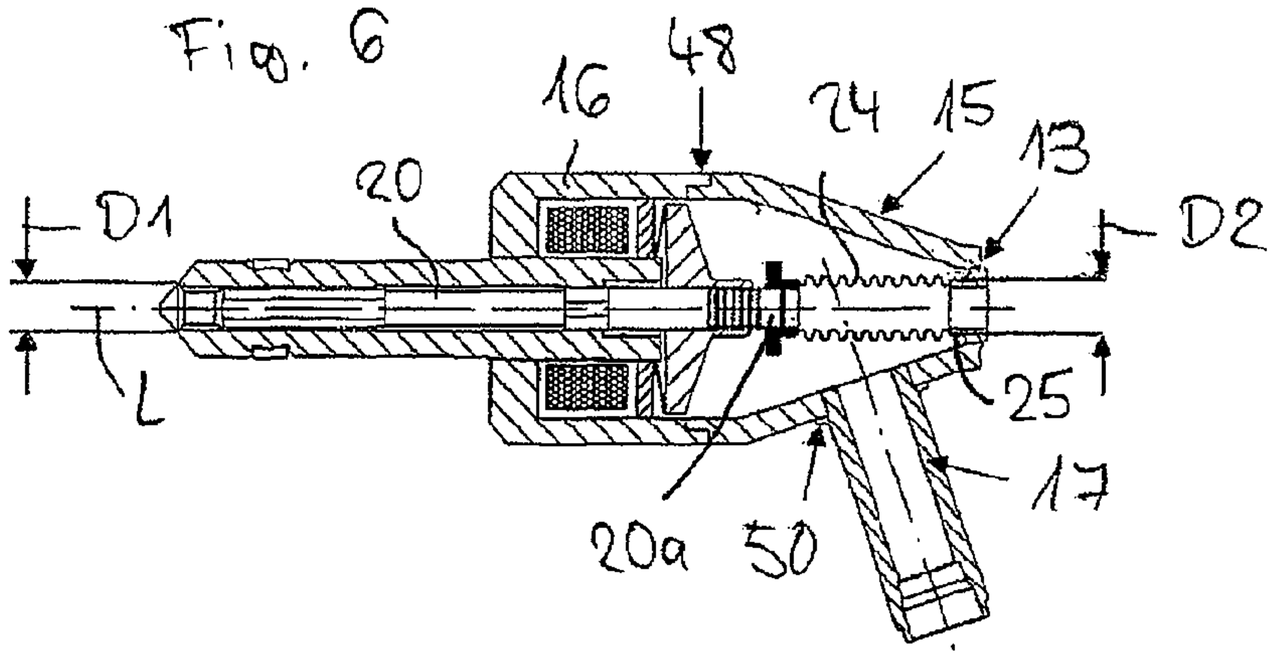


Fig. 6a

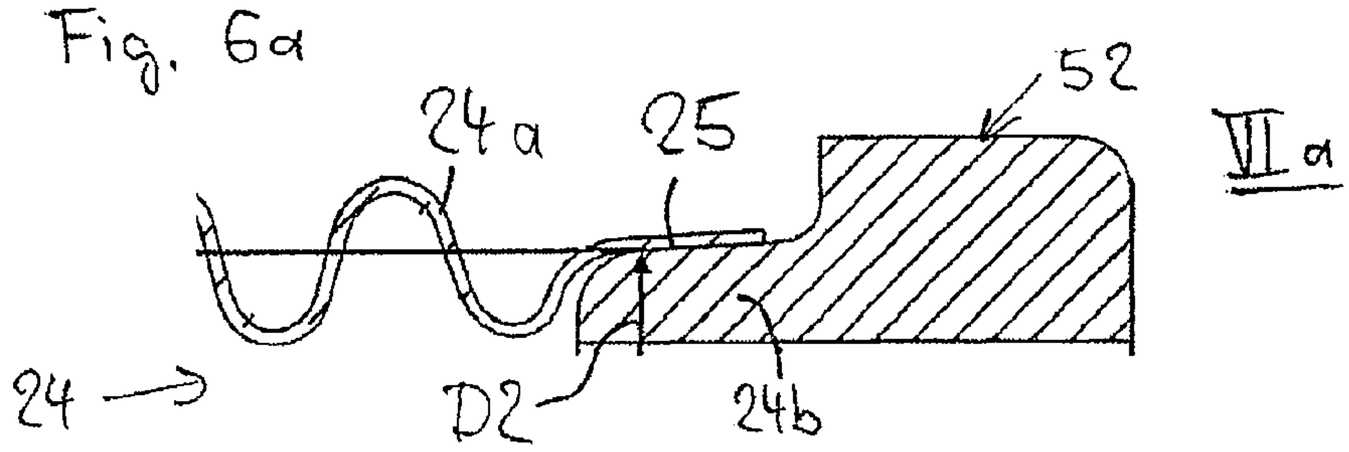


Fig. 7

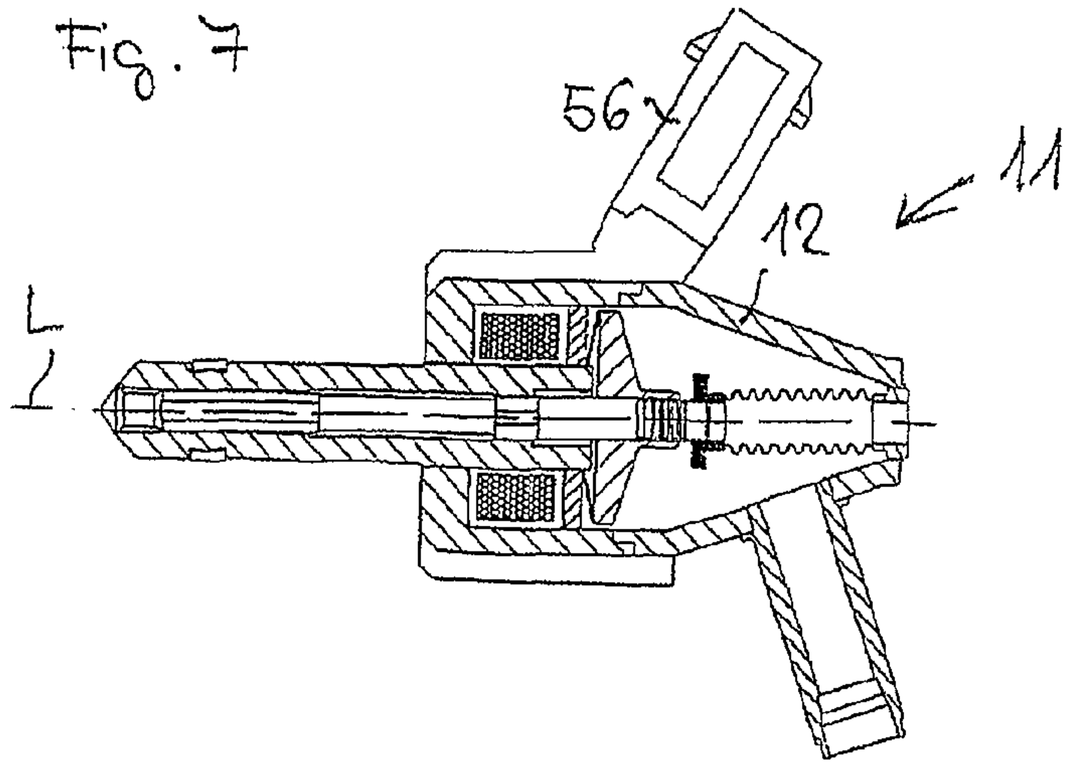


Fig. 8

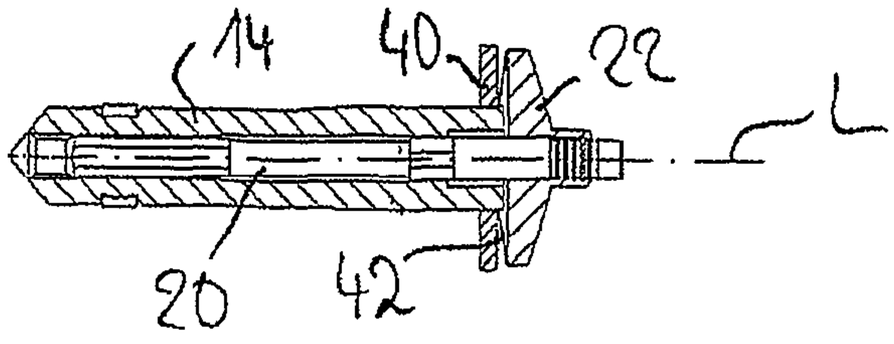


Fig. 9

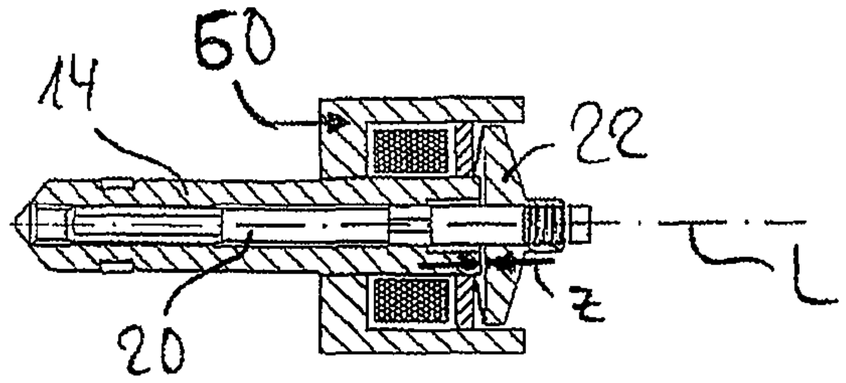


Fig. 10

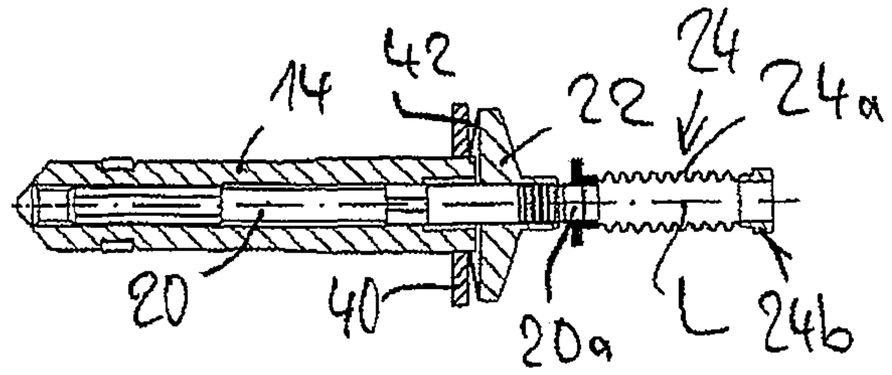


Fig. 11

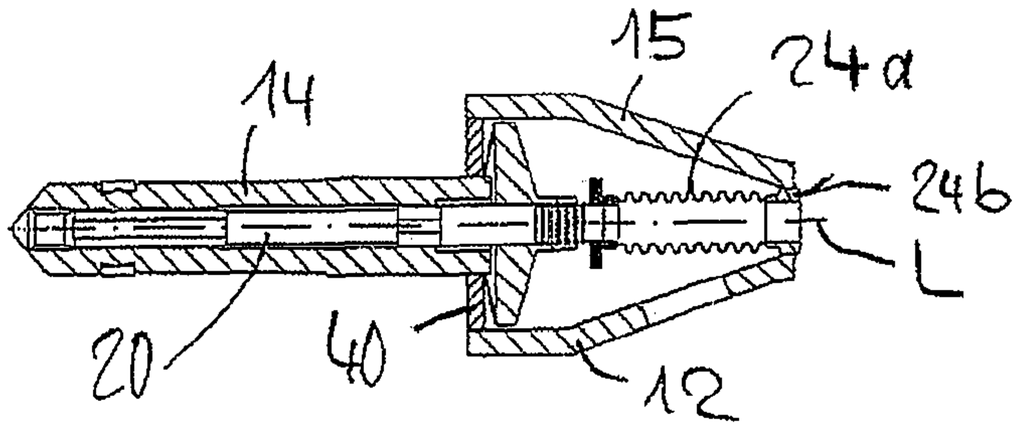
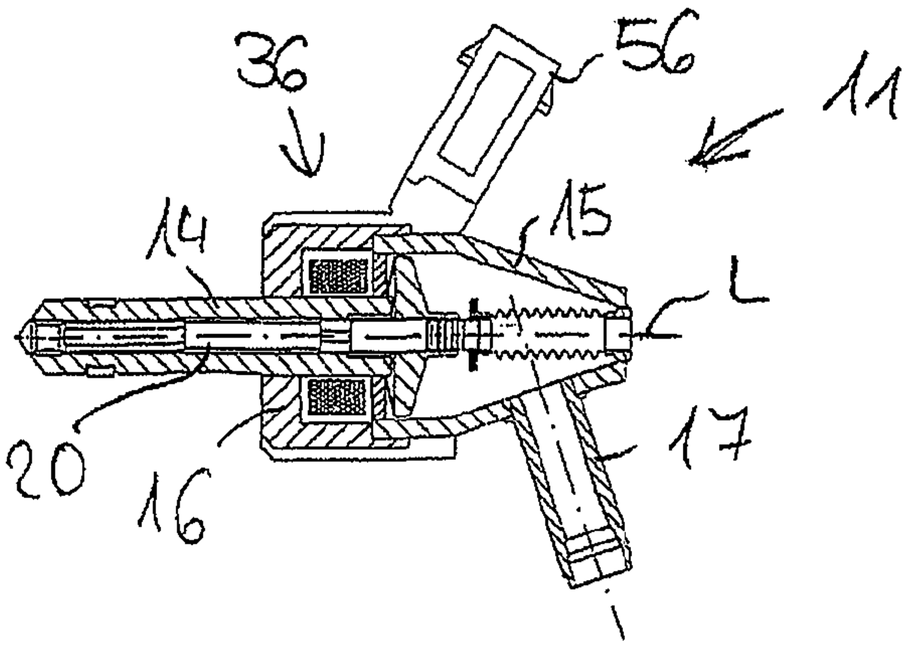


Fig. 12



VALVE ASSEMBLY FOR AN INJECTION VALVE, INJECTION VALVE AND METHOD FOR ASSEMBLING A VALVE ASSEMBLY OF AN INJECTION VALVE

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a U.S. National Stage Application of International Application No. PCT/EP2011/053627 filed Mar. 10, 2011, which designates the United States of America, and claims priority to EP Application No. 10002813.3 filed Mar. 17, 2010, the contents of which are hereby incorporated by reference in their entirety.

TECHNICAL FIELD

This disclosure relates to a valve assembly for an injection valve, to an injection valve and to a method for assembling a valve assembly of an injection valve.

BACKGROUND

Injection valves are in wide spread use, in particular for internal combustion engines where they may be arranged in order to dose the fluid into an intake manifold of the internal combustion engine or directly into the combustion chamber of a cylinder of the internal combustion engine.

Injection valves are manufactured in various forms in order to satisfy the various needs for the various combustion engines. Therefore, for example, their length, their diameter and also various elements of the injection valve being responsible for the way the fluid is dosed may vary in a wide range. In addition to that, injection valves may accommodate an actuator for actuating a needle of the injection valve, which may, for example, be an electromagnetic actuator or piezo electric actuator.

In order to enhance the combustion process in view of the creation of unwanted emissions, the respective injection valve may be suited to dose fluids under very high pressures. The pressures may be in case of a gasoline engine, for example, in the range of up to 200 bar and in the case of diesel engines in the range of up to 2000 bar.

SUMMARY

In one embodiment, a valve assembly for an injection valve includes a valve body, a valve needle, an electro-magnetic actuator unit, a ring element, an armature support spring, and a bellow arrangement. The valve body includes a central longitudinal axis, a cavity with a fluid inlet portion and a fluid outlet portion, an end portion being arranged at an axial end facing away from the fluid outlet portion, a seat being arranged at an axial end of the valve body facing the fluid outlet portion, and a valve cartridge and a housing. The valve needle is axially movable in the cavity, and prevents a fluid flow through the fluid outlet portion in a closing position and releasing the fluid flow through the fluid outlet portion in further positions. The valve needle comprises an axial needle end facing away from the fluid outlet portion and facing the end portion of the valve body, and a seat part resting on the seat of the valve body in the closing position, a contact area between the seat part and the seat of the valve body having a first outer diameter. The electro-magnetic actuator unit is designed to actuate the valve needle and comprising an armature. The ring element is arranged in the cavity radially between the cartridge and the housing and axially between the coil and the armature. The armature support spring is arranged in the cavity axially between the ring element and the armature. The bellow arrangement comprises a bellow and an end portion, the bellow being fixedly coupled to the end portion in a coupling area. The bellow is fixedly coupled to the axial end of the valve needle, and the end portion of the bellow arrangement is fixedly coupled to the end portion of the valve body, the bellow arrangement is sealingly coupling the valve body with the valve needle, the coupling area having a second outer diameter, with the first outer diameter being equal to the second outer diameter.

In another embodiment, an injection valve includes a valve assembly as described above.

In another embodiment, a method for assembling a valve assembly of an injection valve comprises the following steps: providing a valve cartridge and a valve needle, the valve cartridge comprising a cavity, arranging the valve needle in the cavity of the valve cartridge, providing an armature and coupling the armature to the valve needle, providing a reference electro-magnetic actuator and coupling the reference electro-magnetic actuator to the valve cartridge, activating the reference electro-magnetic actuator to cause an axial movement of the valve needle and determining a lift of the axial movement of the valve needle, fixedly coupling the armature to the valve needle, and decoupling the reference electro-magnetic actuator from the valve cartridge.

In a further embodiment, after the reference electro-magnetic actuator is decoupled from the valve cartridge, a housing containing a coil is fixedly coupled to the valve cartridge, wherein the housing and the coil are part of an electro-magnetic actuator unit. In a further embodiment, after the valve cartridge is provided, a ring element is fixedly coupled to the valve cartridge. In a further embodiment, after the valve needle is arranged in the cavity of the valve cartridge, an armature support spring is coupled to the valve needle.

In another embodiment, a method for assembling a valve assembly of an injection valve comprises the following steps: providing a valve cartridge and a valve needle, the valve cartridge comprising a cavity, fixedly coupling a housing containing a coil to the valve cartridge, wherein the housing and the coil are part of an electro-magnetic actuator unit, arranging the valve needle in the cavity of the valve cartridge, providing an armature and an armature support spring and coupling the armature and the armature support spring to the valve needle, activating the electro-magnetic actuator unit to cause an axial movement of the valve needle and determining a lift of the axial movement of the valve needle, fixedly coupling the armature to the valve needle, and fixedly coupling a bellow arrangement to the valve needle.

BRIEF DESCRIPTION OF THE DRAWINGS

Example embodiments will be explained in more detail below with reference to figures, in which:

FIGS. **1** and **1***a* illustrate an injection valve with a valve assembly in a longitudinal section view,

FIG. **2** illustrates parts of the valve assembly in a longitudinal section view,

FIG. **3** illustrates parts of the valve assembly in a longitudinal section view,

FIGS. **4** and **4***a* illustrate parts of the valve assembly,

FIG. **5** illustrates parts of the valve assembly in a longitudinal section view,

FIGS. **6** and **6***a* illustrate parts of the valve assembly in a longitudinal section view,

FIG. **7** illustrates parts of the valve assembly in a longitudinal section view,

FIG. **8** illustrates parts of the valve assembly in a longitudinal section view,

FIG. **9** illustrates parts of the valve assembly in a longitudinal section view,

FIG. **10** illustrates parts of the valve assembly in a longitudinal section view,

FIG. **11** illustrates parts of the valve assembly in a longitudinal section view, and

FIG. **12** illustrates parts of the valve assembly in a longitudinal section view.

DETAILED DESCRIPTION

Some embodiments provide a valve assembly of an injection valve, an injection valve and a method for assembling a valve assembly of an injection valve which facilitate a reliable and precise function of the injection valve.

For example, some embodiments provide a valve assembly for an injection valve, comprising a valve body including a central longitudinal axis. The valve body comprises a cavity with a fluid inlet portion and a fluid outlet portion, an end portion being arranged at an axial end facing away from the fluid outlet portion, and a needle seat being arranged at an axial end facing the fluid outlet portion. The valve assembly comprises a valve needle axially movable in the cavity, the valve needle preventing a fluid flow through the fluid outlet portion in a closing position and releasing the fluid flow through the fluid outlet portion in further positions. The valve needle comprises an axial needle end facing away from the fluid outlet portion and facing the end portion of the valve body, and a seat part resting on the needle seat of the valve body in the closing position, a contact area between the seat part and the seat of the valve body having a first outer diameter. The valve assembly comprises an electro-magnetic actuator unit being designed to actuate the valve needle. A bellow arrangement comprises a bellow and an end portion. The bellow is fixedly coupled to the end portion of the bellow arrangement in a coupling area. The bellow is fixedly coupled to the axial end of the valve needle, and the end portion of the bellow arrangement is fixedly coupled to the end portion of the valve body in a coupling area. The bellow arrangement is sealingly coupling the valve body with the valve needle, the coupling area having a second outer diameter. The first outer diameter is equal to the second outer diameter.

This may reduce the overall cost of the valve assembly due to the low costs of the components of the electro-magnetic actuator and due to low scrap costs. In particular, no thermal compensator is necessary. Additionally, due to the equal diameters the hydraulic forces acting on the valve needle and acting on the bellow are balanced independent of the fluid pressure. Consequently, a high stability of the jet of the injected fluid is possible.

Other embodiments provide an injection valve including a valve assembly as described above.

Other embodiments provide a method for assembling a valve assembly of an injection valve. The method comprises the following steps: providing a valve cartridge and a valve needle, the valve cartridge comprising a cavity, arranging the valve needle in the cavity of the valve cartridge, providing an armature and coupling the armature to the valve needle, providing a reference electromagnetic actuator and coupling the reference electro-magnetic actuator to the valve cartridge, activating the reference electro-magnetic actuator to cause an axial movement of the valve needle and determining a lift of the axial movement of the valve needle, fixedly coupling the armature to the valve needle, and decoupling the reference electro-magnetic actuator from the valve cartridge. The reference electro-magnetic actuator is an actuator which may be used to determine the lifts of the valve needles of a sequence of valve assemblies in a reproducible manner. The lift of the axial movement of the valve needle is an important parameter for an amount of fluid being injected by the valve assembly of the injection valve. Thus, the lift of the axial movement of the valve needle can be determined without using the electro-magnetic actuator unit of the valve assembly. Therefore, scrap costs in view of the electro-magnetic actuator unit of the valve assembly can be kept low.

In one embodiment, after the reference electro-magnetic actuator is decoupled from the valve cartridge a housing containing a coil is fixedly coupled to the valve cartridge. The housing and the coil are part of the electro-magnetic actuator unit. Thus, the housing and the coil of the electro-magnetic actuator unit can be coupled to the valve body in the end of the assembly process. Consequently, low scrap costs in view of electro-magnetic actuator components during the assembly process of the valve assembly are possible.

An injection valve **10** is in particular suitable for dosing fuel to an internal combustion engine which is of an outward opening type and comprises a valve assembly **11**. The valve assembly **11** comprises a valve body **12** with a central longitudinal axis L. The valve body **12** has an end portion **13** which is arranged at an axial end of the valve body **12**. The valve body **12** has a valve cartridge **14**, a valve cap **15** and a housing **16** which is partially arranged around the valve cartridge **14**. The valve assembly **11** comprises an inlet tube **17** which is fixedly coupled to the valve body **12**. In particular, the inlet tube **17** is fixedly coupled to the valve cap **15**.

The valve body **12** has a cavity **18**. On one of the free ends of the cavity **18**, a fluid outlet portion **19** is formed which is closed or open depending on the axial position of a valve needle **20**. The valve needle **20** is arranged in the cavity **18** and is axially movable in the cavity **18**. The valve needle **20** has an axial end **20***a* which faces away from the fluid outlet portion **19** and faces the end portion **13** of the valve body **12**.

The injection valve **10** further has a fluid inlet portion **21** which is hydraulically coupled to the cavity **18** and to a not shown fuel connector which is coupled to the inlet tube **17**. The cavity **18** takes in an armature **22** which is axially movable in the cavity **18**. The armature **22** is fixedly coupled to the valve needle **20**. The armature **22** has apertures **23** which extend in axial direction and allow a fluid flow through the armature **22** (FIG. **4***a*).

Between the valve needle **20** and the valve body **12** a bellow arrangement **24** is arranged which has a bellow **24***a* and an end portion **24***b*. The bellow **24***a* of the bellow arrangement **24** is fixedly coupled to the end portion **24***b* of the bellow arrangement **24** in a coupling area **25**. The bellow arrangement **24** is sealingly coupling the valve body **12** with the valve needle **20** so that a fluid flow between the cavity **18** and the ambiance can be prevented. A calibration spring **26** is arranged inside the bellow arrangement **24**. The calibration spring **26** is mechanically coupled to the axial end **20***a* of the valve needle **20**. The valve needle **20** forms a first seat for the calibration spring **26**. A piston **28** is partially arranged inside the bellow arrangement **24** and forms a further seat for the calibration spring **26**. During the manufacturing process of the injection valve **10** the piston **28** can be axially moved into the bellow arrangement **24** in order to preload the calibration spring **26** in a desired manner. By this the calibration spring **26** exerts a force on the valve needle **20** towards an injection opening **30**.

The valve body **12** has a seat **32** which is arranged at an axial end of the valve body **12** facing the fluid outlet portion **19**. In a closing position of the valve needle **20** a seat part **34**

of the valve needle **20** sealingly rests on the seat **32** by this preventing a fluid flow through the injection opening **30**. A contact area between the seat part **34** and the seat **32** of the valve body **12** defines a first outer diameter D**1**. The coupling area **25** between the end portion **24***b* of the bellow arrangement **24** and the bellow **24***a* has a second outer diameter D**2**. The first outer diameter D**1** is equal to the second outer diameter D**2**. As the diameters D**1**, D**2** are equal, the valve needle is hydraulically equilibrated for every pressure. Therefore, the dynamic behavior of the injection valve **10** can be independent of the fluid pressure. Consequently, a high stability of the jet of the injected fluid is possible. If the injection valve **10** is used in an internal combustion engine a high stability of the jet of injected fuel allows performing a stratified combustion in a combustion chamber of the combustion engine. A further advantage of the pressure balanced valve is that it has no upper functional limits in terms of operative pressure. Consequently, the only upper limit of operative pressure is related to the valve structural resistance.

The valve assembly **11** comprises an electro-magnetic actuator unit **36**. The actuator unit **36** comprises a coil **38**, which may be arranged inside the housing **16** and which is over-molded. Furthermore, the actuator unit **36** comprises the armature **22**. Parts of the valve body **12**, the housing **16** and the armature **22** are forming an electromagnetic circuit. The electro-magnetic actuator unit **36** can be manufactured with low costs. Furthermore, the electro-magnetic actuator unit **36** does not need a thermal compensator as the components of the electro-magnetic actuator unit **36** may have similar thermal expansion coefficients. A ring element **40** is arranged in the cavity **18** radially between the cartridge **14** and the housing **16** and axially between the coil **38** and the armature **22**. The ring element **40** is fixedly and sealingly coupled to the cartridge **14** and the housing **16**. The ring element **40** may comprise a non-magnetic material. An armature support spring **42** is arranged in the cavity **18** axially between the ring element **40** and the armature **22**. The armature support spring **42** may be a belleville spring. The armature support spring **42** has apertures which allow a fluid flow through the armature support spring **42** in axial direction. The armature support spring **42** is supported by the ring element **40**.

In the following, a method for assembling the valve assembly **11** according to the FIGS. **2** to **7** is described in detail: The valve cartridge **14** and the ring element **40** are provided. The ring element **40** is welded to the valve cartridge **14** along a welding line **44** (FIG. **2**). Subsequently, the housing **16** and the coil **38** are provided and are fixedly coupled to the cartridge **14** and the ring element **40**. The housing **16** may be soldered to the ring element **40** to obtain a sealed coupling (FIG. **3**). In the following the valve needle **20** is provided and inserted into the cartridge **14**, and the armature support spring **42** and the armature **22** are coupled to the ring element **40**. Subsequently, the coil **38** is electrically activated and a lift Z of the valve needle **20** is determined. The armature **22** is fixedly coupled to the valve needle **20**, e.g., by crimping (FIG. **4**). In the following, the bellow arrangement **24** is fixedly coupled to the axial end **20***a* of valve needle **20**, e.g., by press-fitting and soldering along a circumference line **46** (FIG. **5**). Subsequently, the valve cap **15** is soldered to the housing **16** along a circumference line **48** and is fixedly coupled to the end portion **24***b* of the bellow arrangement **24** along the circumference line **52**. The inlet tube **17** is fixedly coupled to the valve cap **15** along a circumference line **50** (FIG. **6**, **6***a*). According to FIG. **7**, subsequently, the valve assembly **11** is overmolded and an electric connector **56** is fixedly coupled to the valve assembly **11**. Finally, a calibration process is carried out, by compressing the calibration spring **26** by the piston **28** until the desired amount of fuel is injected. After the calibration process, the piston **28** is fixedly coupled to the end portion **24***b* of the bellow arrangement **24**, e.g., by soldering along a circumference line **54** (FIG. **1**).

In the following, a further method of assembling the valve assembly **11** is described in detail (see FIGS. **8** to **12**): The valve cartridge **14** and the ring element **40** are provided and fixedly coupled to each other. The valve needle **20** is arranged in the valve cartridge **14**, and the armature **22** and the armature support spring **42** are coupled to the valve needle **20** (FIG. **8**). In the following, a reference electromagnetic actuator **60** is provided and coupled to the valve cartridge **14** and to the ring element **40** (FIG. **9**). The reference electromagnetic actuator **60** has the task to determine the lifts of valve needles of a sequence of valve assemblies in a production process in a reproducible manner. The reference electromagnetic actuator **60** is electrically activated to cause an axial movement of the valve needle **20** and to determine the lift Z of the axial movement of the valve needle **20** (FIG. **9**). The reference electromagnetic actuator **60** is decoupled from the cartridge **14** and the bellow arrangement **24** is fixedly coupled to the axial end **20***a* of valve needle **20** (FIG. **10**). In the following, the valve cap **15** is fixedly coupled to the ring element **40** and to the end portion **24***a* of the bellow arrangement **24** (FIG. **11**). Subsequently, the housing **16** containing the coil **38** is fixedly coupled to the valve cap **15** and the valve cartridge **14**. Then, the valve assembly **11** is overmolded and the electric connector **56** is coupled to the valve assembly **11** (FIG. **12**). Finally, a calibration process is carried out as described above for the process according to the FIGS. **1** to **7**.

In the following, the function of the injection valve **10** is described according to FIG. **1***a:*

Pressurized fluid is flowing through the inlet tube **17** to the fluid inlet portion **21** inside the valve body **12**. The fluid passes the armature **22** and the armature support spring **42**. Subsequently, the fluid is flowing in direction to the fluid outlet portion **19** between the cartridge **14** and the valve needle **20** (fluid directions according arrows F). An electrical activation of the coil **38** produces electromagnetic force acting on the armature **22** in direction to the cartridge **14**. The electrical activation of the coil **38** causes an electromagnetic flux in the cartridge **14**, the housing **16** and the armature **22** (magnetic flux directions according arrows M). As the ring element **40** is of a non-magnetic material the magnetic flux generated by the coil **38** is focused to the armature **22**.

Therefore, the armature **22** receives a high force in direction to the cartridge **14**, and the armature **22** moves in direction to the cartridge **14** until it comes into contact with the cartridge **14**. As the valve needle **20** is fixedly coupled to the armature **22**, the valve needle **20** is pushed in an outward direction. Consequently, fluid can flow from the fluid outlet portion **19** through the injection opening **30**.

What is claimed is:

1. Valve assembly for an injection valve, comprising:

a valve body including a central longitudinal axis, the valve body comprising:

a cavity with a fluid inlet portion and a fluid outlet portion,

an end portion at an axial end facing away from the fluid outlet portion,

a seat arranged at an axial end of the valve body facing the fluid outlet portion, and

a valve cartridge and a housing,

a valve needle axially movable in the cavity, the valve needle preventing a fluid flow through the fluid outlet

portion in a closing position and releasing the fluid flow through the fluid outlet portion in further positions, the valve needle comprising:

an axial needle end facing away from the fluid outlet portion and facing the end portion of the valve body, and

a seat part resting on the seat of the valve body in the closing position, wherein a contact area between the seat part and the seat of the valve body has a first outer diameter,

an electro-magnetic actuator unit configured to actuate the valve needle and comprising an armature and a coil,

a ring element arranged in the cavity radially between the cartridge and the housing and axially between the coil and the armature,

an armature support spring arranged in the cavity axially between the ring element and the armature,

a bellow arrangement comprising a bellow and an end portion, the bellow fixedly coupled to the end portion in a coupling area,

wherein the bellow is fixedly coupled to the axial end of the valve needle, and the end portion of the bellow arrangement is fixedly coupled to the end portion of the valve body, and

wherein the bellow arrangement is sealingly coupling the valve body with the valve needle, the coupling area having a second outer diameter, with the first outer diameter being equal to the second outer diameter.

2. The valve assembly of claim **1**, wherein the cartridge is provided for receiving the valve needle.

3. The valve assembly of claim **1**, wherein the coil of the actuator unit is arranged inside the housing.

4. The valve assembly of claim **3**, wherein the housing is partially arranged around the valve cartridge.

5. An Injection valve comprising:

a valve body including a central longitudinal axis, the valve body comprising:

a cavity with a fluid inlet portion and a fluid outlet portion,

an end portion arranged at an axial end facing away from the fluid outlet portion,

a seat arranged at an axial end of the valve body facing the fluid outlet portion, and

a valve cartridge and a housing,

a valve needle axially movable in the cavity, the valve needle preventing a fluid flow through the fluid outlet portion in a closing position and releasing the fluid flow through the fluid outlet portion in further positions, the valve needle comprising:

an axial needle end facing away from the fluid outlet portion and facing the end portion of the valve body, and

a seat part resting on the seat of the valve body in the closing position, wherein a contact area between the seat part and the seat of the valve body has a first outer diameter,

an electro-magnetic actuator unit configured to actuate the valve needle and comprising an armature and a coil,

a ring element arranged in the cavity radially between the cartridge and the housing and axially between the coil and the armature,

an armature support spring arranged in the cavity axially between the ring element and the armature,

a bellow arrangement comprising a bellow and an end portion, the bellow fixedly coupled to the end portion in a coupling area,

wherein the bellow is fixedly coupled to the axial end of the valve needle, and the end portion of the bellow arrangement is fixedly coupled to the end portion of the valve body, and

wherein the bellow arrangement is sealingly coupling the valve body with the valve needle, the coupling having a second outer diameter, with the first outer diameter (D**1**) being equal to the second outer diameter.

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